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Research Note

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DETERMINING THE MOISTURE CONTENT OF SOME DEAD FOREST FUELS USING A MICROWAVE OVEN

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ABSTRACT

This note describes tests conducted to evaluate performance of a standard kitchen-type microwave oven for determining moisture content of dead woody fuels. Procedures are suggested for using the microwave oven to obtain fuel moisture information. Examples are also provided of field use.

KEYWORDS: Forest fuels, fuel moisture, prescribed fire

In order to employ the newest guidelines for prescribed forest burning and to use modern fire behavior models, fire managers must know, with good accuracy, the moisture content of the forest fuels.

At present, the most widely available means of determining the moisture content of fuel samples is by gravimetric determination (commonly called ovendrying). Representative fuel samples are gathered from the site to be burned, placed in airtight containers and taken to a facility where they can be weighed, dried, and then weighed again after drying. Using a standard drying oven, this process is completed in about 24 hours. This procedure serves the needs of fire research, but presents a dilemma to the operational prescribed burner. He or she must know the moisture contents before ignition to be assured that conditions are right for achieving the desired fire treatment. A means is needed to learn the moisture content of forest fuels sampled from the planned or expected fire area, shortly after the samples are gathered.

Standard, commercially available kitchen microwave ovens offer a solution. Palmer and Pace (1974) have suggested the use of microwave ovens for determining fuel moisture of wildland fuels. Using chamise and manzanita as test fuels they conclude that drying fuel in a microwave oven offers an economical, rapid method for measuring fuel moisture content. More recently, Hankin and Sawhney (1978) have shown the advantages of using the microwave oven to determine the moisture content of soil samples.

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Tests of this kind of oven were performed at the Northern Forest Fire Laboratory. Dead, woody fuels with a moisture content below 20 percent can be dried in a matter of minutes and even very wet samples (200 percent MC) could be brought to ovendry condition in a very short time (less than one-half hour).

BACKGROUND

The moisture content of dead forest fuels, especially the duff, has been consistently identified as a critical variable in prescribed burning (Norum 1976; Beaufait, Hardy, and Fischer 1977; VanWagner 1972). Both fire control and the work done by prescribed fires is strongly influenced by fuel moisture contents. Also, duff moisture content is a particularly important factor in determining the impact of prescribed fire on the soil (Shearer 1975). In some cases a small change in fuel moisture content may make a significant difference in the effects of prescribed fires or the behavior of wildfires. In those cases, no estimate of the fuel moisture content should be used except that gained from a sampling of the actual fuels to be burned.

Various means of estimating the moisture content of forest fuels have been tried, and some are commonly used. Traditionally, 1/2-inch ponderosa pine fuel moisture indicator sticks have been used to evaluate moisture content of dead fuels for prescribed burning of logging slash. Some experienced fire mangers have found these analogs of fuel moisture useful in judging the probable fire behavior of planned fires (Morris 1966). The relevance of fuel moisture sticks to the actual moisture content of logging slash has, however, been seriously questioned by Peck (1969). He found that fuel stick moisture content had no predictable value for any of the fuels he examined. Beaufait, Hardy, and Fischer (1975) found a very low correlation coefficient when they compared actual moisture contents to fuel stick moisture content. Some computational procedures employ environmental parameters to calculate various burning indexes. For some purposes, these indexes are adequate, but where prescribed burning guidelines or fire behavior models indicate a response that is sensitive to changes in fuel moisture content, they should not be used to make fire decisions. Serious errors in fire treatment or poor prediction of fire behavior can result.

McLeod (1976) recently developed a prototype portable microwave moisture meter that has shown much promise for measuring moisture content of forest fuels. Tests of this instrument are still being conducted, and final determination of its accuracy is still to be accomplished. Consequently, even with the best results, such an instrument will not be generally available for several years. The use of a microwave oven offers an alternative, if proper procedures are followed.

PROCEDURE

The procedure is basically quite simple although certain precautions must be taken. Fuel samples are gathered, usually by size class or type, from points distributed across the area to be burned. Each sample is weighed before drying to get its weight. It is then placed in the microwave oven for a period of time sufficient to drive off all of the contained water, and then it is weighed again to get its dry weight. The moisture content is then calculated from the simple equation:

$$\%\ \text{Moisture content} = \frac{(\text{Wet weight} - \text{Dry weight})}{\text{Dry weight}} \times 100$$

When using a microwave oven, containers made of nonmetallic material must be used. They should also be nonabsorbent because the weight of water in some fuel samples may be quite small, and any water driven from the container itself will enter as an error if the fuels are weighed in the containers. Also, the containers should be fairly flat and wide rather than tall and thin. The top or bottom of a glass petri dish was found to be an ideal container. Even in flat, wide containers, it is advisable to periodically (every 5 minutes) carefully stir wet, compact samples such as moist duff in order to ensure complete drying.

Most microwave ovens are currently designed to work with some "load" in them when they are turned on. This means that some microwave absorbing material should be in the cavity to avoid damage to the oven. Moistened sponges serve very well. During the tests, three or four 3x5x1/2-inch sponges were wetted, gently wrung out, and placed on the floor of the oven against the walls. Care should be taken to be sure they are kept moist but not soaked during the fuel drying process.

TEST STUDY

Fresh duff and dead branchwood of Douglas-fir and western larch was collected from forests near Missoula, Montana. Duff and 0-1/4-inch dead, woody fuels were tested separately. These materials were separated into lots and conditioned for various levels of moisture content. Samples of about 40 grams each were mixed thoroughly and halved. One half was dried in a standard oven for 24 hours, and the other half dried in a microwave oven. The microwave dried samples were removed from the oven at the end of successive three-minute cycles, stirred and weighed until no further weight loss was detected. The wettest duff samples (230 percent) reached the ovendry state after eight cycles, or 24 minutes in the oven. The wettest 0-1/4-inch samples (90 percent) dried completely in six cycles, or 18 minutes of drying.

Ninety-six pairs of 0-1/4-inch samples and 105 pairs of duff samples were processed. Comparing the results shows a simple linear correlation coefficient of 0.99 for the duff samples and 0.99 for the 0-1/4-inch samples, indicating the microwave ovendrying gave the same results as standard ovendrying. The range of duff moisture content samples was 5 percent to 230 percent and the 0-1/4-inch moisture content ranged from 10 percent to 90 percent.

CONCLUSIONS

The procedure described for microwave ovendrying of dead, woody fuels gave the same results as standard ovendrying. The differences are certainly small enough to be expected, and can be attributed to sampling variability. Some additional trial runs were made using different cycles times, but no signficant changes in procedure are suggested. There does seem to be a slight advantage in uniformity of results and rapidity of drying when 5-minute cycles are used. A total drying time of 25 minutes for very wet duff and 20 minutes for very wet twigs should be adequate if the samples are carefully stirred at intervals of 3 to 5 minutes. A dry glass rod or some similar instrument should be used for stirring, and great care must be taken to ensure that no material adheres to the rod or is lost from the container.

FIELD USE

Microwave ovens are being successfully used for drying fuels under field conditions, powered by light portable electric generators. To minimize the risk of damage to the oven when traveling over rough roads, shock mounting with modified aircraft-type shock mounts intended for electronic equipment is advisable. If the oven is transported in the open bed of a pickup, some sort of weatherproof dust cover is needed.

An example of a field-going microwave oven outfit is the one being used by Fire Management Officer George Ogden on the Bonner's Ferry Ranger District of the Kaniksu National Forest in Idaho (fig. 1). George's outfit consists of four pieces; a standard kitchen-type microwave oven, a shock-mounted platform, a portable 3000-watt generator (fire camp type), and a triple beam balance. These items are shown packed for transport in figure 2 (the platform would be in place under the oven during transport and use). The oven and balance are cushioned with foam rubber to avoid damage during transport (fig. 3 and 4).

With a microwave oven and a reasonably accurate scale, the moisture content of fuels sampled from a proposed fire area can be determined on site in less than one-half hour. This, combined with carefully written prescriptions (Fischer 1979), provides the fire manager with the means to make better decisions leading to improved fire treatments. The same technique, using fire behavior models, will lead to better predictions of the behavior of wildfires and offer sound information for suppression strategies.

SAFETY PRACTICES

Medical authorities feel that microwave ovens may interfere with the normal operation of medical electronic devices, such as cardiac pacemakers. Consequently, people using such devices should not operate microwave ovens.

Other safety practices recommended are:

1. Have oven tested at least once a year for radio frequency leakage.
2. Do not use the oven if the door does not close and latch firmly against the oven front.
3. Periodically check door for worn hinges, torn or twisted door seal, and any other visable sign of damage.
4. Do not try to use the oven with the door open and do not attempt to defeat any interlocks.

The procedures recommended here are for drying dead, woody fuels only. They do not apply to live, green fuels. An acceptable microwave oven procedure for obtaining accurate live fuel moisture contents has not yet been developed.

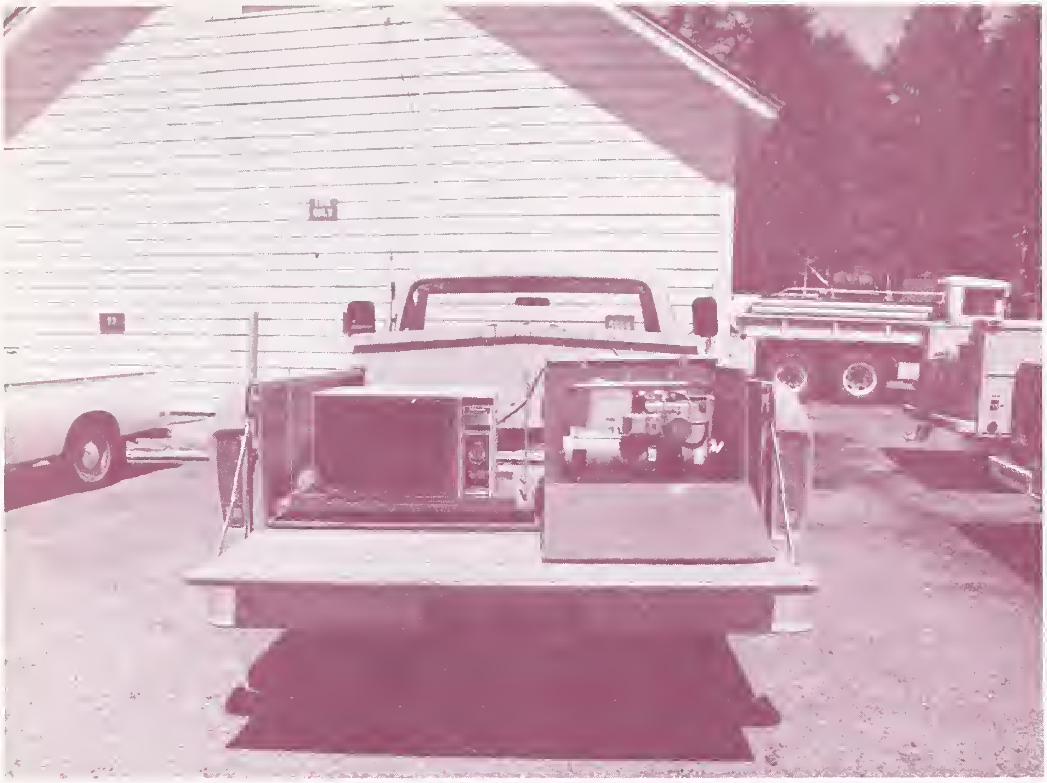

Figure 1. Pickup mounted microwave oven and generator ready for use.

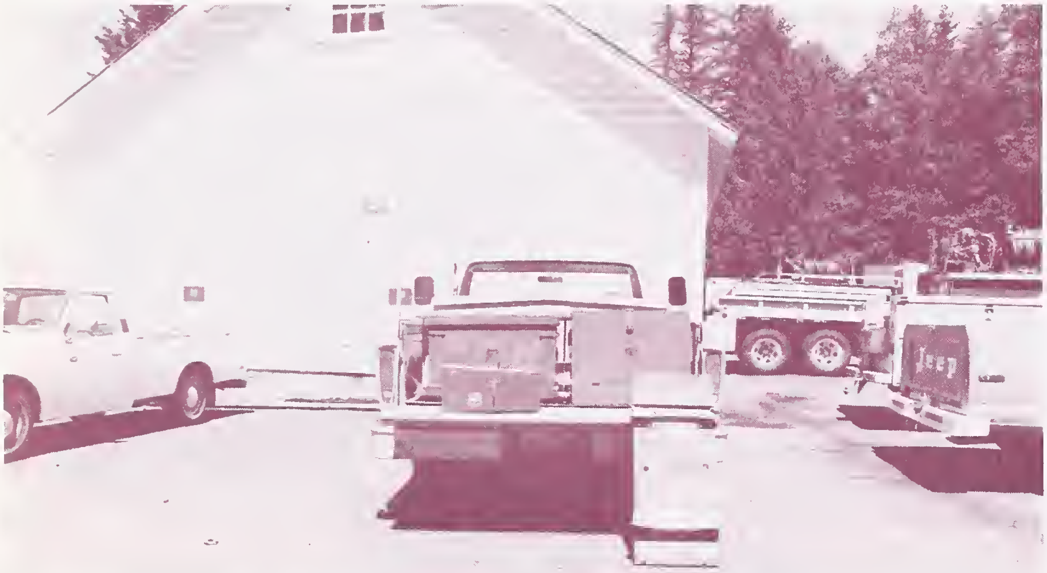

Figure 2. Field-going microwave outfit ready for transport. Oven is on the left, generator on the right. Small box contains scale. Shock mounted platform would be in place under oven during transport.

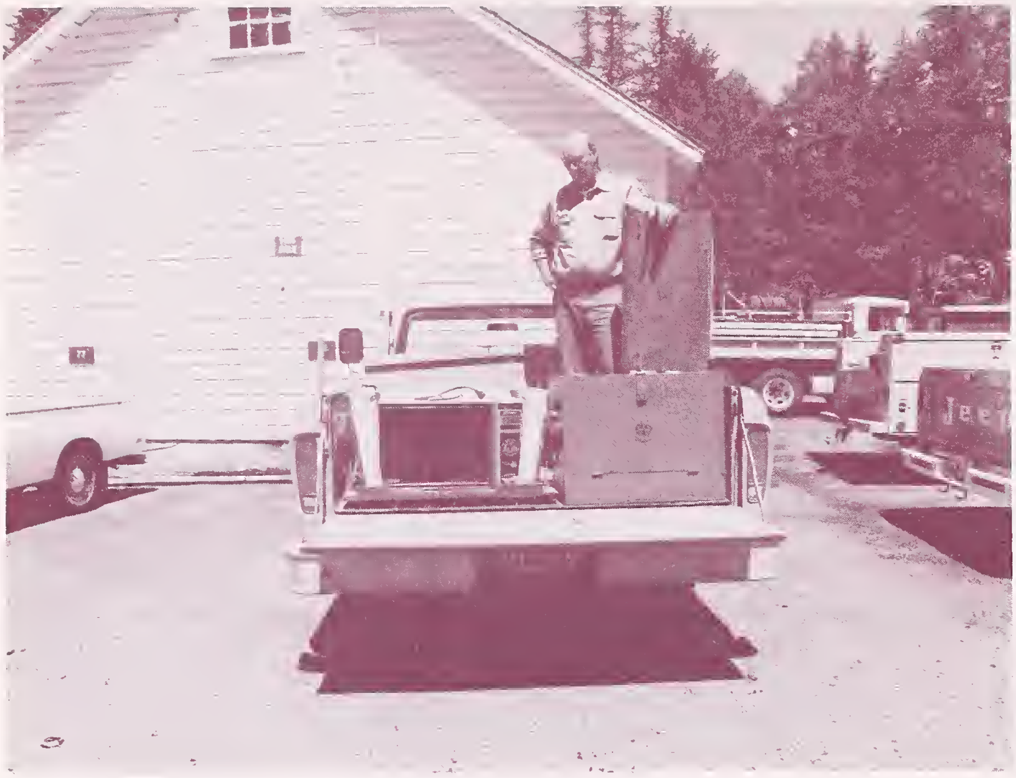

Figure 3. Thick foam rubber cushions the oven during transport.

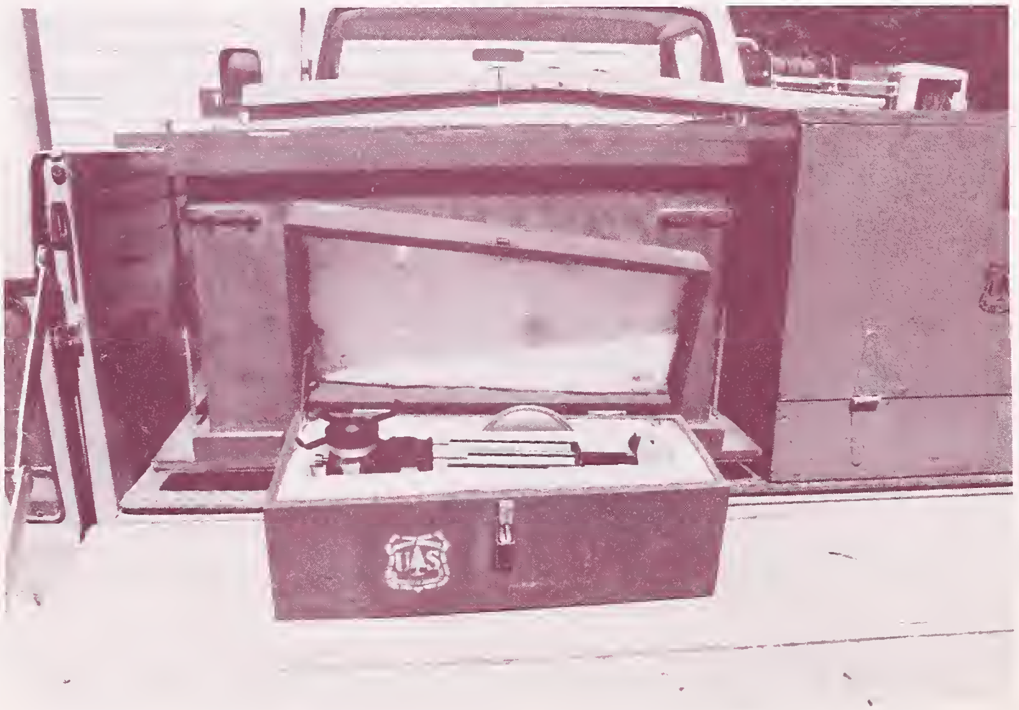

Figure 4. Triple beam balance is transported in foam rubber-lined case.

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